भारतीय मानक
Indian Standard

IS 17374 : 2020

भूकृत्रिम — तरल अपशिष्ट और रासायनिक संरक्षण लाइनिंग के लिए प्रबलित एच डी पी ई मेम्ब्रेन — विशिष्टि

Geosynthetics — Reinforced HDPE Membrane for Effluents and Chemical Resistance Lining — Specification

ICS 59.080.70

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भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in   www.standardsbis.in

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Geosynthetics Sectional Committee, TXD 30

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Textile Division Council.

Reinforced HDPE membranes are highly beneficial and widely used because of their manifold features. They are made of the material which is highly stable and are able to maintain long-term reliability and durability. Reinforced HDPE membrane are extremely useful for large applications that require UV and ozone resistance, chemical resistance or high quality installations and for the control of unsafe liquids and chemicals that could pollute the surrounding if not enclosed correctly.

Reinforced HDPE membranes are tailored products that can be customized as per the need of the customers and are hugely in demand because of their environmental friendly characteristics and compliance to safety standard.

The committee has reviewed the provisions of the following International Standard/Other publication referred in this standard and has decided that these are acceptable for use in conjunction with this standard:

International Standard/ Other Publication	*Title*
ISO 11357-6 : 2018	Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
ASTM D 5885 : 2017	Standard test method for oxidative induction time of polyolefin geosynthetics by high-pressure differential scanning calorimetry

The guidelines and method for installation of reinforced HDPE membrane is given in Annex J for information only.

Resistance chart for HDPE which shows the effects of various chemicals is given in Annex K for guidance only.

The composition of the Committee responsible for the formulation of this standard is given in Annex L.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GEOSYNTHETICS — REINFORCED HDPE MEMBRANE FOR EFFLUENTS AND CHEMICAL RESISTANCE LINING — SPECIFICATION

1 SCOPE

1.1 This standard prescribes requirements for reinforced high density polyethylene (HDPE) membrane laminated with low density polyethylene (LDPE) or suitable combination of low density polyethylene (LDPE) and linear low density polyethylene (LLDPE) for use as proper disposal of domestic and industrial effluents, solid wastes sights and sewage pond, in oil exploration industry, dairy industry, sugar industry, pharmaceutical industry, distillery, agrochemicals, and mining etc.

1.2 The tests used to characterize the reinforced HDPE membrane are intended to ensure good workmanship and quality and are not necessarily adequate for design purposes in view of the importance of environmental factors and specific performance objectives. Other tests are necessary to establish chemical resistance and durability under the condition of particular application as per Annex H.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 MATERIAL AND MANUFACTURE

3.1 Reinforced HDPE membrane shall be manufactured from HDPE fabric (*see* IS 6899) to meet the final requirement of mass (g/m^2) as given in Table 1. The HDPE woven fabric shall be laminated with low density polyethylene film (LDPE) or with suitable combination of LDPE and linear low density polyethylene (LLDPE). The coating film shall be UV stabilized by incorporating UV stabilizer and/or carbon black to enhance the performance of membranes. The film, if manufactured by using carbon black, shall contain minimum 2.5 percent of carbon black by mass with satisfactory dispersion when tested as per IS 2530.

3.2 A suitable multi-layer membrane with adequate number of layers shall be produced using a combination of HDPE fabric and layers of coating film. LDPE impervious film of adequate thickness shall also be incorporated in the manufacturing of membrane. The LDPE impervious film shall be manufactured from virgin polyethylene resins which shall be UV stabilized by adding suitable UV stabilizer.

3.3 Two or more layers of HDPE fabric (*see* Table 1) shall be bonded together by sandwich lamination.

NOTE — Lamination is very important and critical requirement for the product and its proper process control shall be ensured during manufacturing.

4 TYPES

Based on the thickness and mass, in g/m^2, of reinforced HDPE membrane for effluents and chemical resistance lining, the material is classified as below:

a) *Type I* — Having thickness of 0.30 mm and mass of 300 g/m^2, *Min*;
b) *Type II* — Having thickness of 0.50 mm and mass of 420 g/m^2, *Min*;
c) *Type III* — Having thickness of 0.75 mm and mass of 650 g/m^2, *Min*;
d) *Type IV* — Having thickness of 1.00 mm and mass of 950 g/m^2, *Min*;
e) *Type V* — Having thickness of 1.5 mm and mass of 1 200 g/m^2, *Min*; and
f) *Type VI* — Having thickness of 2.0 mm and mass of 1 500 g/m^2, *Min*.

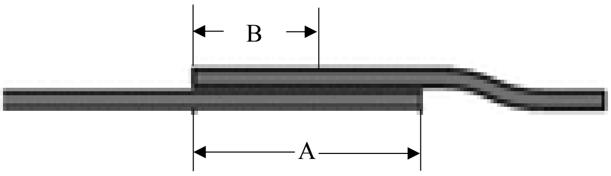
5 REQUIREMENTS

5.1 Workmanship

The reinforced HDPE membrane for effluents and chemical resistance lining shall be uniform in colour, texture and finish. It shall be free from pin holes, undispersed raw material, particles of foreign matter, etc, and the laminated film shall not peel off from the fabric. The minimum width of the fabric panel shall be 1 800 mm. A combination of panel width may be used to obtain desired width of reinforced HDPE membrane liner. Narrow width panel of any width to get the desired finish width may also be used but such pieces shall not exceed 1 piece per roll/piece of finished material of specified width. Cross joint may be used at the rate of one in every third panel.

5.2 Joints/Seams

If two or more panel of reinforced HDPE membrane for effluents and chemical resistance lining are used, the panel shall be joined/seamed by a suitable heat sealing process keeping an overlap of at least 60 mm and sealing shall be minimum 30 mm as shown in Fig. 1.



A: *Min* overlapping width = 60 mm
B: *Min* sealing width = 30 mm

FIG. 1 OVERLAPPING AND SEALING OF MEMBRANES

5.3. Reinforced HDPE membrane for effluents and chemical resistance lining shall conform to the requirements given in Table 1.

5.4 After exposing the reinforced HDPE membranes to chemicals/effluents as per the test method given in Annex H, membranes shall meet the requirements given in Table 2.

NOTE — Depending upon the end use, membrane may be tested for acid, base, fuel, synthetic leachate or any other site specific chemical or effluent. Membranes may be tested for more than one chemical/effluents specified above.

6 PACKING AND MARKING

6.1 Packing

The reinforced HDPE membrane for effluents and chemical resistance lining shall be packed in roll/pieces form or as agreed to between the buyer and the seller. The rolls/pieces shall be packed by HDPE fabric laminated on both sides with LDPE or of the same construction and specifications as that of the rolls/pieces.

6.2 Marking

6.2.1 The reinforced HDPE membrane for effluents and chemical resistance lining rolls/pieces shall be marked legibly with the following information:

a) Indication of the source of manufacture;
b) Type of reinforced HDPE membrane;
c) Declared length and width of the reinforced HDPE membrane;

Table 1 Requirements of Reinforced HDPE Membrane for Effluents and Chemical Resistance Lining

(*Clauses* 3.1, 3.3 *and* 5.3)

Sl No.	Characteristic	Requirement						Method of Test, Ref to
		Type I	Type II	Type III	Type IV	Type V	Type VI	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	Thickness (mm), *Min*	0.3	0.5	0.75	1.0	1.5	2.0	IS 7016 (Part 1)
ii)	Mass (g/m^2), *Min*	300	420	650	950	1 200	1 500	IS 7016 (Part 1)
iii)	Dimensions (length and width)	← As declared + 1 percent with no negative tolerance →						Annex B of IS 11652
iv)	Carbon black content, percent, *Min*	← 2.5 →						IS 2530
v)	Carbon black dispersion	← Satisfactory →						IS 2530
vi)	Breaking load on 20 cm × 10 cm strip before UV exposure, N, *Min*							IS 16635
	a) Warp way	5 000	8 000	13 000	16 000	18 000	24 000	
	b) Weft way	4 500	7500	11 500	15 500	17 200	22 500	
vii)	Strain at maximum load, percent	← 20 to 30 →						IS 16635
viii)	Retention of breaking load on 20 cm × 10 cm strip after UV exposure of 144 h							Annex B and IS 16635
	a) Warp way	← 85 percent of the actual original value →						
	b) Weft way	← 85 percent of the actual original value →						
ix)	Impact failure load, at 1524 mm drop, *Min* gram force at 50 percent failure	1250	1850	3000	4500	5000	6000	Annex C

Table 1 (*Concluded*)

<table>
<tr><th>Sl No.</th><th>Characteristic</th><th colspan="6">Requirement</th><th>Method of Test, Ref to</th></tr>
<tr><th></th><th></th><th>Type I</th><th>Type II</th><th>Type III</th><th>Type IV</th><th>Type V</th><th>Type VI</th><th></th></tr>
<tr><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th><th>(5)</th><th>(6)</th><th>(7)</th><th>(8)</th><th>(9)</th></tr>
<tr><td>x)</td><td>Tear resistance, N, <i>Min</i></td><td>125</td><td>275</td><td>350</td><td>400</td><td>450</td><td>500</td><td>A-1 of IS 7016 (Part 3)</td></tr>
<tr><td>xi)</td><td>Puncture resistance, N, <i>Min</i></td><td>350</td><td>600</td><td>750</td><td>950</td><td>1100</td><td>1250</td><td>Annex D</td></tr>
<tr><td>xii)</td><td>Bursting strength (Ball burst), N/cm^2, <i>Min</i></td><td>85</td><td>135</td><td>155</td><td>250</td><td>300</td><td>450</td><td>IS 7016 (Part 6)</td></tr>
<tr><td>xiii)</td><td>Seam strength before UV exposure, N/mm, <i>Min</i></td><td>20</td><td>35</td><td>40</td><td>45</td><td>60</td><td>75</td><td>IS 15060</td></tr>
<tr><td>xiv)</td><td>Seam strength after UV exposure of 144 h, N/mm, <i>Min</i></td><td colspan="6">◄—— 85 percent of the actual original value ——►</td><td>Annex B and IS 15060</td></tr>
<tr><td>xv)</td><td>Hydrostatic resistance before UV exposure, kg/cm^2, <i>Min</i></td><td>15</td><td>25</td><td>35</td><td>50</td><td>75</td><td>85</td><td>Annex E</td></tr>
<tr><td>xvi)</td><td>Hydrostatic resistance after UV exposure of 144 h, kg/cm^2, <i>Min</i></td><td colspan="6">◄—— 85 percent of the actual original value ——►</td><td>Annex B and Annex E</td></tr>
<tr><td>xvii)</td><td>Low temperature crack resistance at minus 30 °C ± 1°C</td><td colspan="6">◄—— No specimen shall damage or broken ——►</td><td>Annex F</td></tr>
<tr><td>xviii)</td><td>Oxidative induction time (OIT), minutes, <i>Min</i></td><td colspan="6"></td><td></td></tr>
<tr><td></td><td>a) Standard OIT</td><td colspan="6">◄—— 100 ——►</td><td>ISO 11357 (Part 6)</td></tr>
<tr><td></td><td>or</td><td colspan="6"></td><td></td></tr>
<tr><td></td><td>b) High pressure OIT</td><td colspan="6">◄—— 400 ——►</td><td>ASTM D 5885</td></tr>
<tr><td>xix)</td><td>Oven ageing at 85°C, Retention of oxidative induction time (OIT) after 90 days, percent, <i>Min</i></td><td colspan="6"></td><td></td></tr>
<tr><td></td><td>a) Standard OIT</td><td colspan="6">◄—— 70 ——►</td><td rowspan="3">Oven method of IS 7016 (Part 8), ISO 11357-6 and ASTM D 5885</td></tr>
<tr><td></td><td>or</td><td colspan="6"></td></tr>
<tr><td></td><td>b) High pressure OIT</td><td colspan="6">◄—— 90 ——►</td></tr>
<tr><td>xx)</td><td>Stress crack resistance, h, <i>Min</i></td><td colspan="6">◄—— 300 ——►</td><td>IS 16346</td></tr>
<tr><td>xxi)</td><td>Abrasion resistance</td><td colspan="6">Loss in breaking strength shall not be more than 15 percent</td><td>IS 14714</td></tr>
<tr><td>xxii)</td><td>Ash content, <i>Max</i>, percent</td><td colspan="6">◄—— 2 ——►</td><td>Annex G</td></tr>
</table>

Table 2 Requirements of Reinforced HDPE Membranes after Treating Against Chemicals

(*Clause* 5.4)

Sl No.	Characteristic	Requirements	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Change in weight, percent	< 2	Annex H
ii)	Change in volume, percent	< 1	Annex H
iii)	Visual observations	No visual signs of degradation	Annex H
iv)	Change in tensile strength, percent	< 20	Annex H and IS 16635
v)	Change in elongation, percent	< 30	Annex H and IS 16635
vi)	Change in 2 percent secant modulus, percent	< 30	Annex H and IS 16475
vii)	Change in seam strength, percent	< 20	Annex H and IS 15060

d) Mass per square meter of the reinforced HDPE membrane;
e) Batch No. and date of manufacture; and
f) Any other information desired by the buy.

6.2.2 BIS Certification Marking

The reinforced HDPE membrane for effluents and chemical resistance lining roll/piece conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the reinforced HDPE membrane for effluents and chemical resistance lining roll/piece may be marked with the Standard Mark.

7 SAMPLING

7.1 Lot

All reinforced HDPE membrane rolls/pieces of same construction and type dispatched to a buyer against one dispatch note shall constitute a lot.

7.2 Unless otherwise agreed to between the buyer and the seller, the number of reinforced HDPE membrane rolls/pieces to be selected at random from a lot shall be as given in column 3 of Table 3.

Table 3 Scale of Sampling

(*Clause* 7.2)

Sl No. (1)	No. of Rolls in Lot (2)	Sample Size (3)	Sub-Sample Size (4)	Permissible No. of Defective Rolls (5)
i)	Up to 50	3	2	0
ii)	51 - 150	5	2	0
iii)	151 - 280	8	3	1
iv)	281 - 500	13	5	2
v)	501 and above	20	5	3

8 NUMBER OF TEST SPECIMENS AND CRITERIA FOR CONFORMITY

Number of test specimens and criteria for conformity shall be as given in Table 4.

Table 4 Number of Test Specimens and Criteria for Conformity

(*Clause* 8)

Sl No. (1)	Characteristic (2)	No. of Rolls (3)	Criteria for Conformity (4)
i)	Material, manufacture, workmanship, joint/seams, thickness, mass, length and width	According to column 3 of Table 3	The defective rolls/pieces do not exceed the corresponding number given in column 5 of Table 3
ii)	All other requirements	According to column 4 of Table 3	All the test specimens shall pass the tests

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
2530 : 1963	Methods of test for polyethylene moulding materials and polyethylene compounds
6359 : 1971	Method for conditioning of textiles
6899 : 1997	Textiles — High density polyethylene (HDPE) woven fabrics — Specification (*second revision*)
7016	Methods of test for coated and treated fabrics:
(Part 1) : 1982	Determination of roll characteristics (*first revision*)
(Part 3) : 1981	Determination of tear strength (*first revision*)
(Part 6) : 1984	Determination of bursting strength (*first revision*)
(Part 8) : 1975	Accelerated ageing
11652 : 2017	Textiles — High density polyethylene (HDPE)/ polypropylene (PP) woven sacks for packaging of 50 kg cement — Specification (*third revision*)
13162 (Part 3) : 1992	Geotextiles — Methods of test: Part 3 Determination of thickness at specified pressures
14714 : 1999	Geotextiles — Determination of abrasion resistance
15060 : 2018	Geosynthetics — Tensile test for joint/seams by wide-width strip method (*first revision*)
16635 : 2017	Geosynthetics — Wide-width tensile test
16346 : 2015	Geosynthetics — Method of test for evaluation of stress crack resistance of polyolefin geomembranes using notched constant tensile load test
16475 : 2015	Geosynthetics — Method of test for determination of 2 percent secant modulus for polyethylene geomembranes

ANNEX B

[*Table* 1, *Sl No*. (viii, xiv, xvi)]

UV RESISTANCE TEST

B-1 To determine the effect of UV radiation and weathering on the breaking strength, seam strength test and hydrostatic resistance test, the HDPE membrane shall be exposed as given in **B-2** and **B-4**.

B-2 TEST CONDITION

The test shall be carried out with fluorescent UV- lamp Type B (313 nm or its equivalent).

The duration of the test shall be 144 h (that is, six days) in continuous mode.

The test cycle shall be: 8 h at 60 ± 3°C with UV-radiation alternating with 4 h at 50 ± 3°C with condensation. Irradiance level throughout the test shall be maintained at 0.63 (+0.03/-0) W/m^2.

NOTES:

1 The UV source is an array of fluorescent lamps (with lamp emission concentrated in the UV range).

2 Condensation is produced by exposing the test surface to a heated, saturated mixture of air and water vapors, while the reverse side of the test specimen is exposed to the cooling influence of ambient room air.

B-3 PREPARATION OF TEST SPECIMENS

B-3.1 Cut 3 test specimens from each direction for testing of breaking strength and 3 specimens for seam strength and hydrostatic resistance test from the test pieces.

B-3.2 Specimens shall not contain dirt, irregular spots, creases, holes or other visible faults.

B-4 TEST PROCEDURE

B-4.1 Determine the original average breaking strength of the membrane as prescribed in IS 16635, seam strength test as prescribed in IS 15060 and hydrostatic resistance test as prescribed in Annex E.

B-4.2 Expose the specimens alternately to ultraviolet light and condensation in respective test cycle in continuous mode for total 144 h.

The type of fluorescent UV-lamp, the timing of the UV and condensation exposure and the temperature of the UV exposure and condensation shall be as specified in **B-2**.

B-4.3 Determine the average breaking strength, seam strength and hydrostatic resistance of the membrane after UV exposure.

B-4.4 Calculate the percent loss of breaking strength, seam strength and hydrostatic resistance for the exposed specimens from the average results as obtained in **B-4.1** and **B-4.3**.

ANNEX C

[*Table* 1, *Sl No*. (ix)]

DETERMINATION OF IMPACT RESISTANCE

C-1 TERMINOLOGY

C-1.1 Impact Failure Load — The load at which 50 percent of the specimens fail when tested by this method.

C-2 ANNULAR SPECIMEN CLAMP

C-2.1 Two Piece Annular Specimen Clamp — Having an inside diameter of 12.7 cm and conforming to the following requirements:

a) The lower or stationary half of the clamp shall be rigidly mounted so that the plan of the specimen is horizontal and at an angle of 90° with respect to the upright shaft-supporting member of the apparatus.
b) The upper or movable portion of the clamp shall be designed to maintain positive and planer contact with the lower portion of the clamp when in position. This portion of the clamp shall be provided with suitable means for maintaining sufficient contact with the lower clamp to hold the specimens firmly in place during the test.
c) Gasketing materials prepared from rubber or similar material shall be affixed to the specimen contact surfaces of both clamps. This provides a cushion which minimizes thickness variation effects and also allows firm gripping of the specimen and minimizes slippage.

C-2.2 Adapter — An electromechanical (pneumatic) or similar suitable device for use in supporting and instantaneously releasing the dart so that it will fall freely on to the centre of test specimen in the specimen holder.

C-2.3 Dart — It consists of 3.81 cm diameter hemispherical head fitted with 0.64 cm diameter shaft 11.5 cm long, to accommodate removable mass. The head shall be constructed of aluminium, phenolic plastic or other low density material of similar hardness. The shaft shall be attached to the centre of the flat upper surface of the head with its longitudinal axis at 90° to the surface. The shaft shall be made of aluminium with a 1.27 cm long steel tip (tip with suitable material) at the end for supporting it in the adapter.

C-2.4 Masses — The stainless steel detachable masses as follows:

One mass of 3 000 ± 5 g, two masses of 1 000 ± 5g each, two masses of 500 ± 2 g each, two masses of 300 ± 2g each, two masses of 200 ± 2 g each and two masses of 100 ± 2g each having approximate dimensions of 8 to 10 cm in diameter and approximately 1 cm thickness with a hole in the centre of minimum 0.65 cm in diameter.

NOTE — Additional masses may be constructed for use, if it is necessary to extend mass beyond that attainable when using all the masses in the set suggested above.

C-2.5 Positioning Device — Means shall be provided for positioning the dart at the following drop heights from the impinging surface of the dart head to the surface of the test specimen:

Positioning	*Drop Height* mm
Normal impact resistant fabric	660
High impact resistant fabric	1524

C-2.6 Cushioning and Shielding Devices — To protect personnel and to avoid damaging of the impinging surface of the dart.

C-3 TEST SPECIMENS

Test specimens shall be large enough to extend outside the specimen clamp gaskets at all points. The specimens shall be representative of the material under test and shall be free from pinholes, wrinkles, folds or other obvious imperfections, unless such imperfections constitute variables under test.

C-4 PROCEDURE

C-4.1 Place the specimen over the bottom portion of the clamp, making certain that it is uniformly flat, free of folds and that it covers the gasket at all points. Clamp the specimen in place of applying annular pressure with the top portion of the clamp. Position the dart vertically with the steel shaft tip inserted in the adapter and the impinging surface of the dart at the appropriate height from the fabric surface. Release the dart. Take care to avoid multiple impacts in cases where the dart bounces off the specimen. Attempt to catch the dart in such cases to prevent damage to the impinging surface.

C-4.2 Observe the failure as any break through the fabric readily by viewing the specimen under back lighting conditions and examine the specimen to determine whether it has failed or not. Use a new specimen for each impact.

C-4.3 Before beginning the test, make a few trial runs to establish approximately the working range of masses which will break the fabric. Then for at least 3 dart masses selected to give percentage failure between 20 and 80, a minimum of 10 test specimens at each dart mass shall be tested.

C-5 DETERMINATION OF IMPACT FAILURE LOAD

Plot the percentage of failures against total mass of the dart on a graph paper and determine the results graphically. Read the value of impact failure load from the graph as the dart mass at which 50 percent of the specimens fail.

ANNEX D

[*Table* 1, *Sl No*. (xi)]

TEST METHOD FOR INDEX PUNCTURE RESISTANCE

D-1 GENERAL

This test method is used to measure the index puncture resistance of reinforced HDPE membrane.

D-2 PRINCIPLE

A test specimen is clamped without tension between circular plates of a ring clamp attachment secured in a tensile testing machine. A force is exerted against the centre of the unsupported portion of the test specimen by a solid steel rod attached to the load indicator until rupture of the specimen occurs. The maximum force recorded is the value of puncture resistance of the specimen.

D-3 APPARATUS

D-3.1 Tensile/Compression Testing Machine, of the constant-rate-of extension (CRE) type.

D-3.2 Ring Clamp Attachment, consisting of concentric plates with an open internal diameter of 45 ± 0.025 mm capable of clamping the test specimen without slippage. A suggested clamping arrangement is shown in Fig. 2. The external diameter is suggested to be 100 ± 0.025 mm. The diameter of the six holes used for securing the ring clamp assembly is suggested to be 8 mm and equally spaced at a radius of 37 mm. The surfaces of these plates can consist of grooves with ‘o’-rings or coarse sandpaper bonded onto opposing surfaces.

D-3.3 Solid Steel Rod, with a diameter of 8 ± 0.01 mm having a flat end with a 45° × 0.8 mm chamfered edge contacting the test specimen’s surface (*see* Fig. 3).

D-4 SAMPLING

D-4.1 Laboratory Sample

For the laboratory sample take a swatch extending the full width of the product, of sufficient length along the selvage from each sample roll so that the requirements of **D-4.2** can be met.

D-4.2 Test Specimens

Select from the laboratory sample, sufficient number of samples each having a minimum diameter of 100 mm to facilitate clamping. Space the specimens along a diagonal on the unit of the laboratory sample. Take no specimens nearer the selvage or edge of the tarpaulin.

D-5 CONDITIONING

Bring the specimens to moisture equilibrium in the atmosphere for testing tarpaulins (65 ± 5 percent relative humidity and at 27 ± 2°C). Equilibrium is considered to have been reached when the increase in the mass of the specimen, in successive weighings made at intervals of not less than 2 h, does not exceed 0.1 percent of the mass of the specimen.

D-6 PROCEDURE

D-6.1 Select the load range of the tensile/compression testing machine such that the rupture occurs between 10 and 90 percent of the full-scale load.

D-6.2 Centre and secure the specimen between the holding plates ensuring that the test specimen extends to or beyond the outer edges of the clamping plates.

D-6.3 Test at a machine speed of 300 ± 10 mm/min until the puncture rod completely ruptures the test specimen.

NOTE — The rate of testing specified is not an indication of the performance of the specimen for its end use.

D-6.4 Read the puncture resistance from the greatest force registered on the recording instrument during the test.

D-7 CALCULATION

Calculate the average puncture resistance and standard deviation for all tests as read directly from the recording instrument.

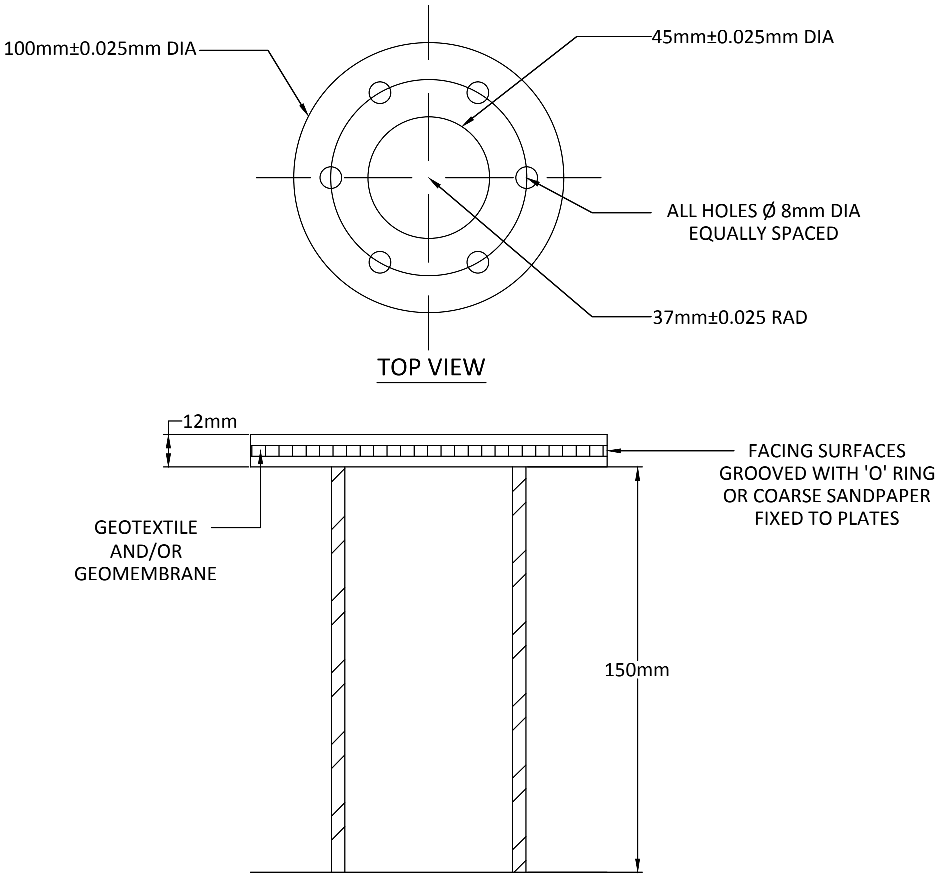


FIG. 2 TEST FIXTURE DETAIL

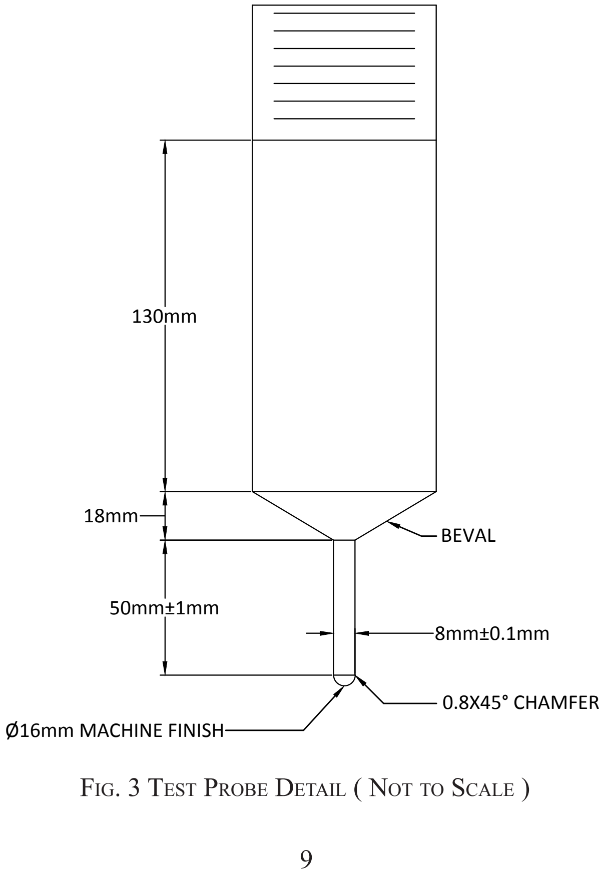


FIG. 3 TEST PROBE DETAIL (NOT TO SCALE)

ANNEX E

[*Table* 1, *Sl No*. (xv, xvi)]

DETERMINATION OF HYDROSTATIC RESISTANCE

E-1 GENERAL

The hydrostatic resistance of reinforced HDPE membrane shall be determined by a Mullen-type hydrostatic tester.

E-2 TESTING MACHINE

The testing machine may be either mechanically or manually operated. It shall permit the clamping of the material to be tested between two circular clamps about 75 mm in diameter having a coaxial apparatus of their centers 31.5 ± 0.5 mm in diameter. The surface of the clamps between which the specimen is to be placed shall be concentrically grooved. The grooves shall be spaced 0.8 mm apart and of a depth not less than 0.15 mm. The grooves shall not start closer than 3.18 mm from the edge of the aperture. The lower clamping surface shall have a recession concentric to the aperture capable of accepting and O-ring having a cross sectional diameter of 4.7 ± 0.1 mm. The machine shall have means of applying hydraulic pressure to the underside of the clamp specimen until the specimen fails. The pressure shall be generated by means of a piston forcing water into the pressure chamber of the apparatus at the rate of 1.4 ± 0.1 cm^3/s. The machine shall be fitted with a pressure gauge maximum-reading type, with a scale divided to read in kg/cm^2 on reading from 0 to 100 kg/cm^2. When the gage is calibrated it shall be mounted in the same relative position as on the bursting tester.

NOTE — Any machine that operates on the same principal and has coaxial apparatus of 31.2+0.5 mm diameter in the clamping surfaces may also be used.

E-3 TEST SPECIMEN

The test specimen cut from the reinforced HDPE membrane shall be of such size that the smallest dimension is at least 12.7 mm greater than the outside diameter of the ring clamp mechanism of the testing machine.

E-4 PROCEDURE

Before clamping the specimen into the testing machine, bring the water level up flush with the top of the lower clamp and the rubber gasket so that no air pocket may exist between the water surface and the reinforced HDPE membrane being tested. The temperature of the water shall be the same as the atmospheric temperature of the testing room. Increase the pressure steadily in the chamber in which a screw shall operate to force a liquid pressure medium at a uniform rate of 1.4 ± 0.1 cm3/s. Take a reading at the first appearance of water through the membrane being tested, make five different determinations and take the average as the hydrostatic resistance of the membrane. Discard an isolated high or low result that is not repeated in duplicate when a consistent average has been obtained without the abnormal reading and substitute a re-test.

ANNEX F

[*Table* 1, *Sl No*. (xvii)]

METHOD FOR DETERMINATION OF LOW TEMPERATURE CRACK RESISTANCE TEST

F-1 PRINCIPLES

Specimens bowed in the shape of a loop are placed in a cooling chamber at minus 30°C and subjected to sudden folding under the impact of a free-falling mass of 500 grams. The test specimen shall not break or damaged.

F-2 APPARATUS

The following description is an example of a typical test apparatus design (*see* Fig. 4).

F-2.1 Impact Device, comprising the following elements:

F-2.1.1 *Specimen Holder*, permitting the fastening of one or more specimens on a platen by means of clamps (for example, leaf springs) to clench each specimen along its entire width (15 mm) and to secure 10 mm of each end of the loop (*see* Fig. 4) so that the length of the loop section subjected to folding is 40 mm.

The platen may be equipped with a mechanism (revolving type) that allows each specimen to be placed

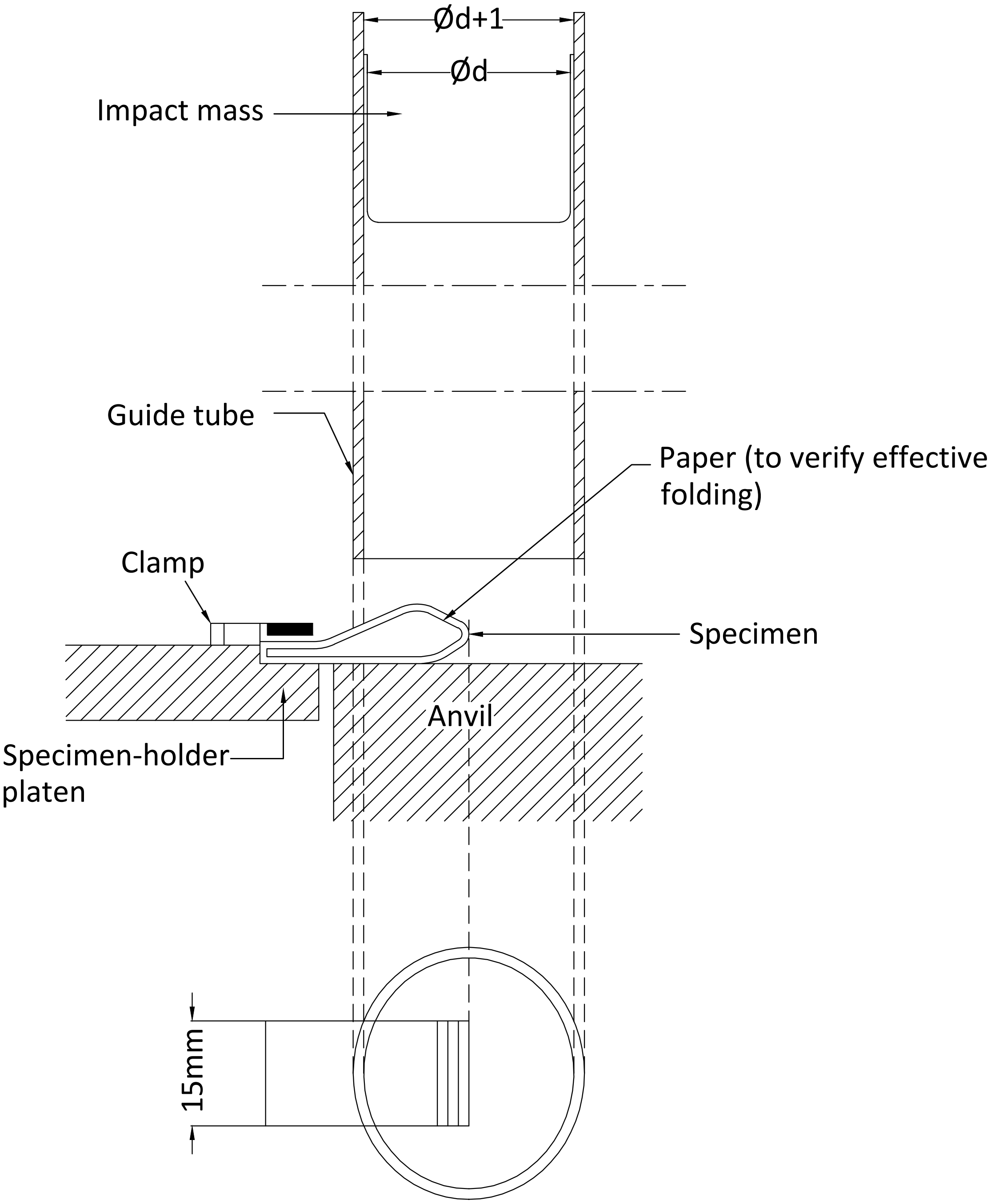


FIG. 4 TYPICAL IMPACT DEVICE FOR DETERMINATION OF COLD-CRACK TEMPERATURE

successively in the test position under the guide tube which guides the impact mass.

F-2.1.2 *Rigid Anvil*, connected to, or part of, the specimen holder and on which the specimen is brought into the test position.

F-2.1.3 *Impact Mass*, 500 g, consisting of metal cylinders with a diameter of not less than 18 mm and not more than 29 mm, the edge of the lower face being slightly rounded.

F-2.1.4 *Guide Tube*, to guide the impact mass equipped at the upper end with a mechanism to release the mass (solenoid or mechanical trigger).This tube, approximately 250 mm long and with a diameter 1 mm larger than that of the impact mass, shall be placed vertically above the specimen test position and shall be mounted so that the drop height, that is, the distance between the base of the impact mass and the anvil, is 200 mm ± 2 mm.

F-2.1.5 *Holding Device*, to align the platen and the guide tube in such a position that the centre of the impact mass coincides with the edge of the flattened loop (20 mm from the clamp).

F-2.2 Cooling Chamber, to house the impact device allowing the temperature to be lowered in steps of 1°C,and able to maintain a temperature constant to within ±1°C.

F-2.3 Thermometer, graduated in 0.5°C, or thermocouple, with an accuracy of 0.5°C, placed in the cooling chamber in the proximity of the specimens.

F-3 SPECIMENS

F-3.1 Shape and Dimensions

The specimens shall consist of strips measuring 60 mm × 15 mm. Their edges shall be free from cuts, scratches and other imperfections.

F-3.2 Number of Specimens

5 specimens shall be taken with their long axis (60 mm) parallel to the machine (that is, longitudinal) direction, and 5 specimens with their long axis parallel to the transverse direction.

F-4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

Condition the test specimens to moisture equilibrium from the dry side in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see also* IS 6359). When the specimens have been left in such an atmosphere so that both the faces are exposed to the standard atmosphere as far as possible for 24 h, they shall be deemed to have reached the state of moisture equilibrium.

F-5 PROCEDURE

F-5.1 Verify the alignment of the guide tube with respect to the position of the specimen on the platen.

F-5.2 Place the impact device containing the mounted specimens in the cooling chamber. When the impact device has reached equilibrium at the test temperature of minus 30 °C (approximately 15 min), position the specimen below the guide tube. Release the impact mass, then reset it to its initial position. Repeat the operation for the other specimens, if any.

Take the platen out of the cooling chamber, remove the specimens and inspect them.

A specimen is deemed to be damaged or broken if any trace of breaking is visible to the naked eye. This trace can be a point or a line, while total rupture may occur, with or without splintering. A whitish line at the fold may occur with certain types of pigmented or un-pigmented material, but this is not considered as a failure.

ANNEX G

[*Table* 1, *Sl No*. (xxii)]

DETERMINATION OF ASH CONTENT

G-1 PRINCIPLE

The procedure is used to find out the inorganic residue in membrane sample by ashing it in a muffle furnace. A weighed amount of membrane sample is heated to 590 °C. The polymer sample (organic portion) is burnt at 590 °C until constant mass of inorganic matter is obtained. The residue (inorganic matter) is reported in terms of percentage ash content in a given sample.

G-2 APPARATUS

G-2.1 Weighing Balance, accurate to 0.001 g.

G-2.2 Silica Crucibles, sufficient volume to accommodate 3 g of sample in such a way that level of the sample after filling the crucible does not cross half the height of crucible.

G-2.3 Bunsen Burner

G-2.4 Silica Triangle and Tripod

G-2.5 Muffle Furnace, capable of being controlled thermostatically at 590 ± 10 °C.

G-2.6 Desiccator, containing an effective drying agent (for example, silica gel) that does not react chemically with ash components.

G-2.7 Gloves and Crucible Holder

G-3 SAFETY

G-3.1 Burn the sample in an effectively ventilated hood.

G-3.2 Keep the hood closed and do not inhale the fumes of combustion.

G-3.3 Wear gloves and use sample (crucible) holder, to introduce crucible in the furnace.

G-3.4 Sample should be folded properly to accommodate it in silica crucible.

G-4 PROCEDURE

G-4.1 Heat the clean crucible at 590 ± 10 °C for 10 to 15 min and cool it in a desiccator.

G-4.2 Weigh the empty crucible to nearest 0.001 g.

G-4.3 Weigh about 3 g of raffia tape/fabric sample in the crucible (nearest to 0.001 g).

G-4.4 Heat the crucible directly on bunsen burner so that the sample burns slowly and loss of ash is avoided. Continue burning until no more smoke is evolved.

G-4.5 Transfer the crucible in the muffle furnace, which is already maintained at approximately 590°C and keep the crucible inside for about 2 h.

G-4.6 Remove the crucible from the furnace and cool it to the room temperature in a desiccator. Weigh it and record the weight to accuracy of 0.001 g.

G-4.7 Keep the crucible in the muffle furnace for another half an hour, cool in a desiccator and weigh again. Repeat the procedure until constant mass is obtained.

G-5 CALCULATIONS

Percent ash content =

$$\frac{\text{Weight of ash} \times 100}{\text{Weight of membrane fabric sample}}$$

ANNEX H

(*Clauses* 1.2, 5.4 and *Table* 2)

TEST FOR EVALUATING THE CHEMICAL RESISTANCE OF REINFORCED HDPE MEMBRANES

H-1 PRINCIPLE

In order to check the resistance of membranes to various chemicals/effluents, the physical and chemical properties of membrane shall be analyzed before and after treating against chemicals/effluents. Depending upon the end use, the membrane shall be exposed to either of three chemical compounds (acid, base and fuel) to assess their chemical degradation. Membrane may also be exposed to a synthetic leachate representative of a landfill containing domestic waste or any site specific leachate.

H-2 APPARATUS

H-2.1 Analytical Balance (accuracy of 0.001 g).

H-2.2 Dead Weight Micrometer(s), (accuracy of 0.002 mm).

H-2.3 Air Circulating Oven, (105 ± 2 °C).

H-2.4 Exposure Tank, for containment of the solution.

H-2.5 Lid, for sealing the exposure tank.

H-2.6 Temperature Control Equipment, in order to maintain the temperature of the immersion solution to 50 ± 2 ºC.

H-2.7 Sample Holder, capable of holding or suspending samples of reinforced HDPE membrane, such that each sample shall be separated by at least 10 mm from all other samples and from the tank wall.

H-2.8 Stirrer, either a magnetically moved stirring bar, or a mechanical stirrer entering the tank through the lid.

H-2.9 Other necessary equipment required to perform the test.

H-3 REAGENTS AND MATERIALS

H-3.1 Exposure under Acidic Conditions — In case of exposure under acidic conditions, a 10 percent solution of sulfuric acid shall be used as immersion solution.

H-3.2 Exposure under Basic Conditions — In case of exposure under basic conditions, a solution containing 2.5 grams of calcium hydroxide per litre, shall be used as immersion solution.

H-3.3 Solvation and Swelling — A mixture of 35 percent diesel fuel by volume, 35 percent paraffin by volume and 30 percent lubricating oil HD 30 by volume shall be used as immersion solution.

H-3.4 Synthetic Leachate — In case of determination of resistance to synthetic leachates, a mixture consisting of following shall be used as immersion solution:

a) 7.5 g/l acetic acid ($C_2H_4O_2$);
b) 2.5 g/l propionic acid (CH_3CH_2COOH);
c) 0.4 g/l isobutyric acid ($(CH_3)_2CHCOOH$);
d) 7.0 g/l butyric acid ($CH_3(CH_2)_2$ COOH);
e) 0.4 g/l isovaleric acid [$(CH_3)_2$.$CHCH_2$ COOH];
f) 1.8 g/l valeric acid[CH_3.$(CH_2)_3$.COOH];
g) 4.5 g/l hexanoic acid [CH_3.$(CH_2)_4$.COOH];
h) 4.0 g/l hentanoic acid [CH_3.$(CH_2)_5$.COOH];
j) 0.2 g/l glucose [$O(CHOH)_4CH.CH_2OH.H_2O$];
k) 0.3 g/l sodium chloride (NaCl);
m) 0.3 g/l anhydrous sodium sulphate (Na_2 SO_4)
n) 0.2 g/l calcium chloride ($CaCl_2.2H_2O$);
p) 0.2 g/l magnesium sulfate ($MgSO_4.7H_2O$);
q) 0.5 g/l diammonium hydrogen phosphate ($(NH_4)_2$ HPO_4 (*see* NOTE); and
r) Deionized water to 1 litre.

NOTE — If not commercially available, this can be replaced by a mixture of 0.44 g/l of 85 percent concentrated phosphoric acid and 0.51 g/l of 25 percent concentrated ammonia.

The *p*H of this synthetic leachate shall be adjusted to a final *p*H of 6 using 16 ml of ammonia solution (4N) and then subsequently with NaOH.

H-3.5 Any Site Specific Leachate — For any site-specific leachate the immersion solution shall be prepared as agreed to between the buyer and the seller.

H-4 SAMPLING AND CONDITIONING

H-4.1 Six samples of dimensions 200 mm × 200 mm (length × width) shall be taken for testing. Three samples shall be taken as control samples for evaluation of properties (*see* column 2 of Table 2) before immersion in test solution (immersion solution) and three samples shall be taken as test samples for evaluation of properties after immersion.

H-4.2 Cut the samples so that they are representative of the reinforced HDPE membrane being evaluated. Discard samples which contain scratches or other imperfections that might affect the test results. Use a die to cut specimens from sheet stock in order to ensure consistency of dimensions.

H-4.3 Conditioning

Prior to the test, specimens shall be conditioned to moisture equilibrium from dry side in standard atmosphere of 65 ± 5 percent relative humidity and 27 ± 2ºC temperature as laid down in IS 6359.

H-5 PROCEDURE

H-5.1 Take 3 control samples each for evaluation of properties given in column 2 of Table 2 as per methods specified in **H-6.1** to **H-6.6**. The average of 3 readings shall be taken for each property.

H-5.2 Now take 3 test samples and immerse in the test solution (immersion solution) as specified in **H-3.1** to **H-3.5**. Test samples shall be immersed in the test solution (immersion solution) at a temperature of 50 ± 2 ºC for a period of 56 days.

H-5.3 Dip the test samples in the exposure tank with a lid sealing the exposure tank. The purpose of the lid is to prevent pressure build up in the exposure tank from gases generated by chemical reactions or biological activity.

H-5.4 Exposure tank shall consists of a temperature control equipment in order to maintain the temperature of the immersion solution to 50 ± 2 ºC.

H-5.5 Hang/suspend the test samples in the sample holder such that each sample shall be separated by other samples and tank walls by at least 10 mm.

H-5.6 After the end of immersion period, cool the tank to room temperature, open the bath and remove the samples for the required testing. Samples shall be rinsed with deionized water and blot dry with water-absorbent, lint-free paper towels to remove any visible liquid or solid residue on the sample surface.

H-5.7 Test samples shall be stored in an airtight container or bag with as little air as possible when not being used or tested in order to minimize moisture or volatile loss, or both.

H-5.8 Now test samples shall be tested for change in properties as specified in **H-6.1** to **H-6.6**.

H-6 REQUIRED TESTING OF HDPE MEMBRANES

H-6.1 Weight Change

Remove three pre-weighed pieces of test sample from the immersion solution, quickly blot dry with water-absorbent, lint-free paper towels for any visible liquid or solid residue on the specimen surface, and weigh to the nearest 0.001 g. Take average of 3 readings for control as well as test samples. Calculate the percent weight change to the nearest 0.1 percent.

H-6.2 Volume Change

Thickness of the samples shall be measured at a pressure of 2 ± 0.01 kPa by Method A of IS 13162 (Part

3) to the nearest 0.002 mm at three locations near the center of the pieces of test sample. Measure length and width (machine and transverse directions) at two locations on the sample used for the physical testing before and after immersion. Take average of 3 readings for control as well as test samples. Calculate volume of specimen before and after immersion. Compute percent changes to the nearest 0.1 percent.

H-6.3 Visual Observations

Samples shall be properly examined before and after immersion. The samples shall be examined for change from original colour, including any mottling; change in surface gloss; change in surface roughness; curling, swelling, or other change at the edges of the specimen; scratch, scoring, fracture initiation, or splitting of specimen into separate parts; and gross specimen changes, such as wrinkling, ovalization, or noticeable curling.

H-6.4 Tensile Strength and Elongation

Samples shall be tested in each direction for control as well as test samples. Measure the tensile strength and elongation at break as per method given in IS 16635. Take average of 3 readings. Calculate percent changes to the nearest 1 percent of control samples and test samples (before and after immersion respectively).

H-6.5 2 Percent Secant Modulus

Samples shall be tested for 2 percent secant modulus for control as well as test samples as per method given in IS 16475. Take average of 3 readings. Calculate percent changes to the nearest 1 percent of control samples and test samples (before and after immersion respectively).

H-6.6 Seam Strength

Control as well as test samples shall be tested for seam strength. Measure the seam strength as per method given in IS 15060. Take average of 3 readings. Calculate percent changes to the nearest 1 percent of control samples and test samples (before and after immersion respectively).

ANNEX J

(*Foreword*)

GUIDELINES FOR INSTALLATION OF HDPE MEMBRANE

J-1 PREAMBLE

J-1.1 The primary function reinforced HDPE membrane applied in ponds/reservoirs is to prevent loss of effluents water due to seepage. The successful performance of HDPE membrane is based on a good quality material, installation and appropriate design of ponds/reservoirs.

J-1.2 To improve the service lifetime of reinforced HDPE membrane, it is essential that the HDPE membrane are placed on the pond/reservoir surface according to the dimensions and contours of the pond/reservoir ensuring full contact with the sub grade. To achieve this onsite laying, joining and fixing is imperative.

J-2 LOGISTICS

Reinforced HDPE membrane are packed and transported by appropriate means to protect the HDPE membrane and avoid any type of damage. Rolls of HDPE membrane are loaded manually/with a crane and tie beam and can be unloaded in a similar manner at the destination. Use of hooks shall be avoided for loading and unloading of the reinforced HDPE membrane at site.

J-3 STORAGE AT SITE

J-3.1 The reinforced HDPE membrane shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage. The rolls shall be stored on a prepared surface and to be stacked not more than three rolls.

J-3.2 The owner of the site where the reinforced HDPE membrane is to be installed shall provide storage space in a location sufficiently near the sub grade to be lined to minimize any additional handling.

J-3.3 The storage area shall be protected from theft, vandalism, vehicular traffic and any other source which could create potential damage to the liner.

J-4 EARTHWORK AND SITE PREPARATION

J-4.1 Site Considerations

J-4.1.1 The site selected for pond/reservoir shall not be within the path so that, it obstructs or impinge the flow of the natural course of the water, rain fed Nallah or a stream as well as in the pathway of concentrated surface runoff from the hills or elevated grounds upstream of the pond/reservoir, as there are chances of underground seepage of water into the pond/reservoir and HDPE membrane is subjected to upliftment.

J-4.1.2 The proposed pond/reservoir site shall not be natural pit, a well or stone mines.

J-4.1.3 The selected site shall be free from hard rocks/ Murrum, a natural water source, mountain etc.

J-4.1.4 The proposed site shall be free of any decomposable organic materials/vegetation as it can result in upliftment due to generation of gases beneath the reinforced HDPE membrane.

J-4.2 Design and Subgrade Preparation

J-4.2.1 The excavation of the pond/reservoir shall be done by means of a JCB or Pock Lain Machine.

J-4.2.2 The slope to bed ratio (V: H) shall be 1:1.5 minimum.

J-4.2.3 The embankments constructed shall be stable, as the unstable embankments will collapse resulting into tensile or tear failure of reinforced HDPE membrane.

J-4.2.4 The top width of the embankment shall be at least 1.5 meter wide.

J-4.2.5 Sub grade surface shall be leveled and made free of undesirable angular and sharp fragments, foreign and organic matter, stones and pebbles, as the presence may lead to cause pinholes and or puncture the reinforced HDPE membrane.

J-4.2.6 Soil sterilization may be necessary to kill roots certain types of grasses by using an effective sterilant/ chemical, however the sterilant or the chemical used shall not be detrimental to the liner and shall be applied in accordance with the reinforced HDPE membrane manufacturer’s recommendations.

J-4.2.7 The bed and slopes of the constructed pond/ reservoir shall be inspected for burrows of crab’s rodents etc. All such burrows shall be emptied by removing the crabs and rodents and disposed off to a safe site away from the pond/reservoir site.

J-4.2.8 The empty burrows and potholes (cavity between the stones) on the bed/slope of pond/reservoir shall be filled with soil. Thereafter it shall be compacted and the entire area shall be cleaned and leveled. The entire area shall be uniform and smooth.

J-4.2.9 A Layer of soft soil shall be applied and the top layer of soft bed and slope shall be compacted by water showering at least 90 percent of proctor density by vibro compaction equipment or by any other suitable equipment or manually.

J-4.2.10 The compaction shall be achieved at least up to a depth of 300 mm from the final sub grade level of inside of the pond.

J-4.2.11 Perfect compaction and leveling of bed and slopes will give good support to the reinforced HDPE membrane.

J-4.2.12 Inlet and outlet structures shall be properly designed, faulty design and construction of inlet and outlet structures shall result in flooding or overtopping of embankments damaging the reinforced HDPE membrane.

J-5 ANCHOR TRENCH

J-5.1 For the purpose of anchoring the reinforced HDPE membrane, an anchor trench of 1 feet × 1 feet × 1 feet shall be excavated at a distance of 80 to 100 cm away from the inside edge of the top of the embankment.

J-5.2 Rounded corners shall be provided in the trench to avoid sharp bends in the reinforced HDPE membrane. It is imperative that the anchor trench is complete in all respects before lining work is undertaken to ensure the speed of lining and schedule.

J-5.3 The anchor trench shall be back filled after filling the pond, till then filled sand bags shall be kept as counter weight.

J-6 COMMENCEMENT OF REINFORCED HDPE MEMBRANE INSTALLATION WORK

J-6.1 Before starting the reinforced HDPE membrane installation the contractor shall issue a certificate of satisfactory site conditions, to enable to commence reinforced HDPE membrane installation work.

J-6.2 Chain linked fencing shall be put around the pond/reservoir to prevent stray entry of men and animals to protect any damage to the reinforced HDPE membrane.

J-7 REINFORCED HDPE MEMBRANE LAYING OPERATIONS

J-7.1 While laying the reinforced HDPE membrane precaution shall be taken to avoid any damage to the lining system.

J-7.2 The reservoir area shall be declared as a ‘NO SMOKING ZONE’ and all personnel will wear flat rubber soled foot wear (similar to bathroom slippers).

J-7.3 The method of unrolling the reinforced HDPE membrane panels shall be such that it shall not cause scratches or crimps in the reinforced HDPE membrane and any damage to the sub grade surface.

J-7.4 Reinforced HDPE membrane panels shall be placed properly on the bed and the slopes with an overlap of 50 to 75 mm for field seaming, or as specified, but not less than 50 mm.

J-7.5 At corners of the pond/reservoir the panels shall be properly matched and laid according to the size and geometry of corners of the embankment slopes (commonly the shape shall be an inverted triangle) and joined with adjacent liner panels on the slope.

J-7.6 Counter weight of filled sand bags along the edges of reinforced HDPE membrane panels and toe of the bunds shall be provided in order to minimize the risk of flow of wind under the panels.

J-7.7 The reinforced HDPE membrane interface where seams are to be made shall be clean and free from dust.

J-7.8 Reinforced HDPE membrane shall not be laid during rains, any precipitation, in the presence of excessive moisture, in an area of standing water, or during high winds, fog, dew etc.

J-7.9 Any area of panel seriously damaged shall be marked and repaired.

J-7.10 Reinforced HDPE membrane deployment shall stop in excessive temperatures since this will result in imperfect seaming.

J-8 FIELD SEAMING OF REINFORCED HDPE MEMBRANE

The fundamental mechanism of seaming reinforced HDPE membrane sheets together is to temporarily reorganize the polymer structure (by melting or softening) of two opposing surfaces to be joined in a controlled manner so that, after the application of pressure, results in the two sheets being bonded together and the joined sheets shall perform as one single reinforced HDPE membrane sheet. Therefore field seaming is a very important and crucial operation and any negligence on this part shall compromise severely the performance of reinforced HDPE membrane system.

J-9 SEAMING OPERATIONS OF REINFORCED HDPE MEMBRANE

J-9.1 Seams shall be oriented parallel to the slope that is, oriented down, not across the slope.

J-9.2 Wherever odd shaped geometric location or corners are identified, the field seams shall be minimized.

J-9.3 Horizontal seam shall be located on the base of the slope, not less than 1.50 meters from the toe of the slope.

J-9.4 When seaming, panels shall be adjusted to ensure that the seams are aligned with the fewest possible number of wrinkles and ‘fish mouths’.

J-9.5 Seaming shall extend to at least 20 cm into the anchor trench. While welding a seam, proper overlap shall be monitored and maintained.

J-9.6 A pressure type joint, employing the SS or HDG flats, neoprene seals, and SS or HDG bolts and nuts shall be used to seal the junctions, inlet and outlet structures and pipes.

J-9.7 Seam area shall be inspected to assure that it is clean and free of moisture, dust, debris of any kind.

J-9.8 Welding technicians shall periodically check the machine operating temperature and speed and shall record this information.

J-10 SINGLE FUSION HOT AIR WELDING

In single fusion hot air welding, a device consisting of a resistance heater, a blower and a temperature controller is used to blow hot air between the two reinforced HDPE membrane sheets in the overlap. The hot air at 400 to 450°C shall melt the reinforced HDPE membrane opposing surfaces.

Immediately following the melting of surfaces, pressure is applied to the seamed area to bond the two sheets using a roller.

J-11 FACTORS AFFECTING THE FIELD SEAMS

J-11.1 Many factors contribute to the quality of field seam, such as ambient temperature, moisture, wind, dust and quality of the field personnel.

J-11.1.1 *Ambient Temperature*

Field seaming shall be performed when weather conditions are favorable. Seaming below 5°C and above 40°C may result in a decrease in the overall quality of installation.

J-11.1.2 *Moisture*

Moisture caused due to precipitation or high humidity is likely to result in improper bonding resulting in failure of seams. Therefore the surface of panel in seaming must remain dry at all times.

J-11.1.3 *Wind*

Winds causing displacement of reinforced HDPE membrane panels may interfere with the proper alignment of seams, resulting in wrinkles or ‘fish mouths’.

J-11.1.4 *Dust*

The reinforced HDPE membrane panels shall be maintained in a broom clean condition with no dust allowed on or near the seaming areas.

J-11.1.5 *Quality of Field Personnel*

The critical parameters for the hot air fusion welding machine are temperature and speed which shall be strictly maintained. Therefore well trained professionals/ technicians shall be employed for field seaming. Excessive melting weakens the reinforced HDPE membrane and inadequate melting results in poor strength. Hence, a well trained technician will be able to apply adequate melting and pressure making proper seams.

J-12 FIELD TESTING OF SEAMS

J-12.1 To ensure the quality of seams, it is necessary to have a check on the seams at site by visual and manual methods to identify any defective field seams involving presence of unbounded or open seams, fish mouth created due to wrinkles and restraints, burning of liner due to excessive heat during thermal bonding.

J-12.2 Any one of the following advance test methods can be performed for testing of seams:

a) Air lance method;
b) Mechanical point stress/pick test; and
c) Vacuum box testing.

J-12.2.1 *Air Lance Method*

The air lance method uses a jet of air at approximately 350 kPa pressure coming through an orifice of 5 mm diameter. It is directed beneath the upper edge of the overlapped seam to detect unbonded areas. When such an area is located, the air passes through causing inflation and fluttering in the localized area. The audible sound also changes when unbonded areas are encountered. This method works on relatively thin, less than 1.00 mm, flexible reinforced HDPE membrane, but it works only if the defect is open at the front edge of the seam where the air jet is directed.

J-12.2.2 *Mechanical Point Stress/ Pick Test*

The mechanical point stress or the pick test uses a dull tool, (such as a blunt screw driver) under the top edge of the seam. With care, an installer can detect an unbonded area which is easier to separate than a properly bonded area. It is a rapid test that obviously depends completely on the care and sensitivity of the person doing it. Detectibility is similar to that using the air lance and both are very operator dependent.

J-12.2.3 *Vacuum Box Test*

A vacuum box assembly consisting of a rigid housing with a transparent window and having a soft rubber gasket attached to the bottom porthole or assembly and a vacuum gauge will be used. Soap solution in plastic bucket with a mop will be made available. The excess sheet overlap if any, shall be properly trimmed away. Then a strip of reinforced HDPE membrane of length 300 mm shall be wetted by the length of box with the soap solution. The box shall be placed over the wetted area and compressed. Create a vacuum of 0.15 kg/cm^2 to 0.35 kg/cm^2. Care shall be taken to ensure that a leak proof seal is created. Vacuum shall be maintained for a sufficient time that is for a period of approx 10 to15 sec. Examine the reinforced HDPE membrane through the viewing window for presence of any soap bobbles. In case no such soap bubbles appear after 10 to15 sec, close the vacuum valve and open the bleed valve. Thereafter move the box over the next area adjoining the tested area with a minimum 75 mm overlap. Repeat the process as described above. In case animated soap bubbles appear, all such areas shall be marked, repaired and then retested.

J-13 POST INSTALLATION PRECAUTIONS

J-13.1 If there is no proposal of fixing cover system over the reinforced HDPE membrane, the pond/reservoir shall be filled as soon as possible after installation work to ensure that the reinforced HDPE membrane fully adheres to the sub grade surface.

J-13.2 The reinforced HDPE membrane shall be loosened from the anchor trench wherever it is found to be stretched, after filling the pond/reservoir.

J-13.3 The inlet pipe through which liquid intake is being done in the pond/reservoir where liquid falls continuously at a particular area, such point shall be fixed with an extra piece of reinforced HDPE membrane to avoid damage at that particular point due to force of the drop.

J-13.4 A reinforced HDPE membrane shall be laid at corner of the pond/reservoir. There are chances of some reptiles entering into the pond, in spite of fencing. These reptiles can’t come out of the pond/ reservoir as they cannot crawl on the Reinforced HDPE membrane. Hence to prevent damage to the reinforced HDPE membrane, shade nets shall be installed at the corners over the reinforced HDPE membrane.

J-13.5 If a submersible pump is used to draw the liquid from the pond/reservoir than an anti-vibration mounting or a float shall be used under the submersible pump.

ANNEX K

(*Foreword*)

CHEMICAL RESISTANCE CHART FOR HDPE MEMBRANES WHICH SHOWS THE EFFECTS ON VARIOUS CHEMICALS

Sl No.	**CHEMICALS**	**TEMP 20ºC**	**RANGE 50ºC**
A	WATER:-		
	Distilled water	E	E
	Raw water	E	E
B	INORGANIC ACIDS :-		
	Boric	E	E
	Butyric	F	X
	Chlorosulphonic	X	-
	Chromic acid (10 percent)	E	X
	Chromic acid (concentrated)	F	-
	Hydrobromic (25 percent)	G	F
	Hydrochloric (10 percent)	E	E
	Hydrochloric (37 percent)	G	G
	Hydrochloric (concentrated)	E	E
	Hydrocyanic	G	G
	Hypo- chlorous	F	X
	Nitric – 5 percent	E	E
	Nitric – 10 percent	E	E
	Nitric – 65 percent	X	X
	Phosphoric – 25 percent	E	E
	Phosphoric – 85 percent	E	F
	Phosphoric – (concentrated)	E	-
	Sulphuric – (10 percent)	E	E
	Sulphuric – (78 percent)	F	F
	Sulphuric – (93 percent)	F	F
C	INORGANIC BASES:-		
	Ammonium hydroxide (10 percent)	E	E
	Ammonium hydroxide (concentrated)	E	E
	Barium hydroxide (concentrated)	E	-
	Calcium hydroxide (10 percent)	E	E
	Potassium hydroxide (10 percent)	E	E
	Sodium hydroxide (10 percent)	E	E
	Sodium hydroxide (concentrated)	E	-

Sl No.	CHEMICALS	TEMP 20ºC	RANGE 50ºC
D	INORGANIC SALTS:-		
	Aluminum chloride	E	E
	Aluminum sulphate	E	E
	Ammonium chloride	E	E
	Ammonium nitrate	E	E
	Ammonium phosphate	E	E
	Ammonium sulphate	E	E
	Ammonium sulphide	E	E
	Barium chloride		
	Barium sulphide	E	E
	Calcium chloride	E	E
	Calcium hypochlorite	E	E
	Cupric chloride	E	E
	Calcium nitrate	E	E
	Calcium sulphate	E	E
	Copper chloride	E	E
	Cupric sulphate	E	E
	Ferric chloride	E	E
	Ferric nitrate	E	E
	Ferrous sulphate	E	E
	Magnesium chloride	E	E
	Magnesium sulphate	E	E
	Mercuric chloride	E	E
	Mercurous chloride	E	E
	Mercurous cyanide	E	E
	Nickel salts	E	E
	Nickel sulphate	E	E
	Potassium chloride	E	E
	Potassium permaganate	G	G
	Potassium bisulphite	E	E
	Potassium dichromate	G	G
	Phosphoric trichloride	E	-
	Potassium borate	E	E
	Potassium chormate	E	E
	Potassium ferrocyanide (saturated)	E	E
	Potassium perborate	E	E
	Potassium nitrate	E	E
	Potassium sulphate	X	-
	Potassium sulphite	E	E
	Potassium perchlorate	E	E
	Sodium nitrate	E	E

Sl No.	CHEMICALS	TEMP 20ºC	RANGE 50ºC
	Sodium sulphate	E	E
	Sodium cynide	E	E
	Sodium hypochloride	E	E
	Sodium chloride	E	E
	Sodium bicarbonate	E	E
	Sodium borate	E	E
	Sodium chloride saturated	E	E
	Sodium carbonate	E	E
	Sodium silicate	E	E
	Sodium sulphite	E	E
	Silver nitrate	E	E
	Sodium hypochlorite (15 percent)	G	G
	Thionyl chloride	X	X
	Trisodium phosphate	E	E
	Zinc sulphate	E	E
	Zinc chloride	E	E
E	ORGANIC ACIDS:-		
	Acetic acid (10 percent)	E-F	E-F
	Acetic acid (glacial)	F	X
	Acetic (75 percent)	E	E
	Adipic acid	E	E
	Benzonic	E	E
	Vutyrc acid	F	X
	Carbonic acid	E	E
	Chloriacetic	E	E
	Citric	G	G
	Formic acid (10 percent)	E	-
	Lactic acid (10 percent)	E	E
	Maleic acid	E	G
	Oletic acid (10 percent)	F	F
	Oleum	X	X
	Oxalic acid	E	G
	Perchloric acid	G	X
	Phthalic acid	E	G
	Phenol (10 percent)	G	X
	Phenol (100percent)	E	-
	Picric acid 910percent)	E	-
	Propionic acid	F	X
	Salicylic acid, Sat	E	E
	Tannic acid (10 percent)	E	-

Sl No.	**CHEMICALS**	**TEMP 20ºC**	**RANGE 50ºC**
	Tartaric acid (10 percent)	E	-
	Trichloroacetic acid	F	X
F	ALCOHOLS:-		
	Amyl alcohol (pure)	E	E
	Allyl alcohol	E	E
	Benzyl alcohol	E	-
	Butyl alcohol	E	F
	Diacetone alcohol	E	F
	Diethylene glycol	E	E
	Dipropylene glycol	E	E
	Ethylene glycol	E	E
	Ethyl alcohol	E	E
	Glycerol	E	-
	I-Hexanol	E	E
	Isobutyl alcohol	E	E
	Isopropyl alcohol	E	-
	2- Methoxyethanol	E	E
	Methyl alcohol	G	F
	n-Butyl alcohol	E	E
	Propyl alcohol	E	E
	Propylene glycol	E	E
	Resorcinol	E	-
	Scc-Butyl alcohol	E	E
	Triethylene glycol	E	E
	Tripropylene glycol	E	E
	Tert-butyl alcohol	E	E
	Undecyl alcohol	E	G
G	ALDEHYDES :-		
	Benzaldehyde	E	-
	Butyraldelhyde	E	-
	Furfural	E	-
	Formaldehyde	E	E
	Salicylaldhyde	E	E
	Glurtaraldehyde (disinfectant)	E	E
	Acetaldehyde	G	F
H	AMINES:-		
	Aniline	E	X
	Triethanolamine	E	-

Sl No.	**CHEMICALS**	**TEMP 20ºC**	**RANGE 50ºC**
	Diethylamine		
I	ESTERS :-		
	Amyl acetate	E	-
	Dibutyl sebacate	E	-
	Dioctyl phthalate	G	F
	Ethyl acetate	E	-
	Methyl acetate	F	F
	Isopropyl acetate	E	G
	Silver acetate	E	E
	Sodium acetate, Sat.	E	E
	Benzyl acetate	E	E
	nButyl acetate	G	F
J	OTHERS :-		
	Dibenzyl ether	F	-
	Diethylene glycol monobutyl ether	F	-
	Ethyl ether	X	X
	Ethylene elycol monoehtyl ether	F	-
	Methyl-t-butyl ether	F	X
	Diethyl benzene	F	X
	Diethyl ether	F	X
	Isopropyl ether	X	X
K	HYDROCARBONS:-		
	Benzene	X	X
	Cyclohexane	G	-
	Cyclopentane	F	X
	Ethylbenzene	F	-
	Gasoline	F	F
	Heptane	G	F
	Hexane	G	-
	Napthalene	E	-
	Toulene	F	X
	Xylene	G	F
L	HALOGENATED HYDROCARBONS :-		
	Benzyl chloride	X	-
	Bromobenzene	F	X
	Bromoform	X	X
	Butyl chloride	X	X

Sl No.	**CHEMICALS**	**TEMP 20ºC**	**RANGE 50ºC**
	n-Butyl acetate	E	G
	Chlorobenzene	X	X
	Chloroform	X	X
	Carbon tetrachloride	F	X
	Cyclohexanol	E	E
	Cyclohexanal	X	X
	Cyclohexanone	X	X
	Dichloroethane	F	F
	o-Dichlorobenzene	G	F
	p-Dichlorobenzene	X	X
	1,2-dichoroethane	X	X
	2,4-Dichlororophenol	X	X
	Ethylene dichloride	X	X
	Isopropyl benzene	F	F
	Methylene chloride	F	X
	Perchloroethylene	X	X
	Trichloro ethylene	X	X
	1,2,4- Trichlorobenzene	X	X
	Trichloroehtane	F	X
M	OTHER SUBSTITUTED HYDROCARBONS:-		
	Nitromethane	F	X
	Carbon di sulphate	X	X
	Nitrobenzene	X	X
N	KETONES:-		
	Acetone	X	X
	Diethyl ketone	G	G
	Methyl ethyl ketone	E	X
	Methyl isobutyl ketone	E	G
	Methyl propyl ketone	E	G
O	DETERGENTS AND OTHER CLEANING PRODUCTS :-	E	E
P	NATURAL FATS AND OILS :	E	E
Q	OILS AND FUELS:	E	-
R	HYDRAULIC FLUIDS :	F	X

Sl No.	CHEMICALS	TEMP 20ºC	RANGE 50ºC
S	GASES:		
	Ammonia	E	E
	Cartionic acid gas	X	X
	Carbon-di-oxide	E	E
	Carbon monoxide	E	E
	Chlorine (dry)	F	F
	Chlorine (wet)	F	X
	Fluorine	G	X
	Hydrogen sulphide	G	G
	Nitrous oxide	E	E
	Ozone (pure)	X	X
	Propane gas	F	X
	Propylene oxide	E	E
	Sulphur Dioxide (wet)	G	G
	Sulphur Dioxide (dry)	G	G
T	OTHERS:-		
	Alum (conc)	E	E
	Aluminium	E	E
	Ammonia (liquid)	F	F
	Beer	E	E
	Bromine	F	F
	Camphor	X	X
	Carbon	E	E
	Castor oil	E	E
	Cider	E	E
	Copper	E	E
	Ether	X	X
	Fluorine	E	F
	Hydrogen	G	G
	Hydrogen peroxide (30/90)	E	E
	Hydrogen peroxide (dilute)	E	G
	Hydrogen peroxide (90 percent)	E	F
	Hydroquinone	E	E
	Iodine (cone sdn.)	G	X
	Nickel	E	E
	Phosphorus	E	X
	Tetrahydroforan 3	X	X

E	EXCELLENT TO DISCERNIBLE ATTACK
G	GOOD, NO SIGNIFICANT ATTACK
F	FAIR, MILD ATTACK LIMITED USE
X	UNACCEPTABLE, PROHIBITED ATTACK.

ANNEX L

(*Foreword*)

COMMITTEE COMPOSITION

Geosynthetics Sectional Committee, TXD 30

Organization	*Representative(s)*
The South India Textile Research Association Council, Coimbatore	Dr A. N. Desai (***Chairman***)
Ahmedabad Textile Industry’s Research Association, Ahmedabad	Shrimati Deepali Plawat Shri Jigar Dave (*Alternate*)
Best Geotechnique Pvt Ltd, Mumbai	Shri Satish Naik
Central Coir Research Institute, Alappuzha	Dr D. Anita Ravindranath Shrimati Sumy Sebastian (*Alternate*)
Central Road Research Institute, New Delhi	Shri Sudhir Mathur Shri Jai Bahagwan (*Alternate*)
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Central Water Commission, New Delhi	Representative
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DKTE Centre of Excellence in Nonwovens, Ichalkaranji	Shri Aniket S. Bhute
Ganga Flood Control Commission, Patna	Shri A. K. Sinha Shri Manoj Kumar (*Alternate*)
Garware Wall Ropes Ltd, Pune	Shri Tirumal Kulkarni Shri Rajendra Ghadge (*Alternate*)
Geosynthetics Testing Services Pvt Ltd, Ahmedabad	Dr Deepak Manjunath
ICAR- National Institute of Natural Fibre Engineering & Technology, Kolkata	Shri Manik Bhowmick Dr Sanjoy Debnath (*Alternate*)
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Indian Jute Industries’ Research Association, Kolkata	Dr Mahuya Ghosh Shri Koushik Das (*Alternate*)
Indian Jute Mills Association, Kolkatta	Shri S. K. Chandra Shri J. K. Behera (*Alternate*)
Indian Technical Textile Association, Mumbai	Dr Anup Rakshit Shrimati Ruchita Gupta (*Alternate*)
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Kusumgar Corporates, Mumbai	Shri Y. K. Kusumgar Dr M. K. Talukdar (*Alternate*)

Organization	*Representative(s)*
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Megaplast India Pvt Ltd, Daman	Shri C. V. Rajesh Shri Hemendra Behera (*Alternate*)
Ministry of Road Transport & Highways, New Delhi	Shri Sanjiv Kumar
Municipal Corporation of Greater Mumbai, Thane	Dr Vishal Ramesh Thombare Shri Mandar Bhalchandra Pingle (*Alternate*)
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The Bombay Textile Research Association, Mumbai	Shri V. K. Patil Dranjan K. Mukhopadhyay (*Alternate*)
The Synthetics & Art Silk Mills Research Association, Mumbai	Dr Manisha Mathur Shrimati Ashwini Sudam (*Alternate*)
In personal capacity [*Bhakta Nivas, 12-1-170/46 P, Hanuman Nagar, Jaipuri Colony, Nagole, Hyderabad 500 068*]	Dr G. V. Rao
In personal capacity [*104, Kanchanban, A. W. Vartak Marg, Vile Parle (East), Mumbai 400 057*]	Shri V. N. Gore
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